Indirect effect of *Moringa oleifera* supplemented diet on growth rates of pre-weaning Boer goat kids

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ABSTRACT: The objective of this study was to evaluate the indirect effects of feeding *Moringa oleifera* (*M. oleifera*) supplemented diet on growth rates in pre-weaning kids. Namibia being a semi-arid and driest country in Africa south of the Sahel, lactating does are challenged with acquiring the required amount of forage in the rangelands to meet milk production and nutritional needs for their kids. This scarcity of forage along with the low nutritional quality of the available grasses and/or browses creates the need for supplementing lactating does with nutritionally-rich fodders. A completely randomized block design (CRBD) was used with four inclusion levels of *M. oleifera* supplemented diets and four replicates of does in each level to determine if the growth parameters differ with levels of *M. oleifera*. A total of 16 lactating does were used for this study with 20 kids since four does had twins. The present study revealed that there were significant differences ($P < 0.05$) in heart girth, body length and weight of kids which were measured as growth rate parameters along with body condition scores (BCS). Although Boer goats are known for their fast growth under favorable conditions, feed supplementation of pregnant and lactating does could be advantageous for maximum milk production to support their kids' healthy early growth and development especially under unfavorable conditions such as during winter and drought. Therefore, in a semi-arid drought persistent country like Namibia, *M. oleifera* would bring a possible solution for animal supplementation during drought and winter periods since *M. oleifera* grows very fast and produces more biomass per hectare; thus, alleviating farmer's stress of purchasing feed-supplement during pregnancy and lactation period.

KEY WORDS: Boer goat kids, Growth rates, lactating does, *Moringa oleifera,* supplemented diet

INTRODUCTION

Goats are very important in areas where feed resources are limited because they can consume a wide variety of plant species and parts and have a great ability to select high quality diets in these circumstances [1], [2]. Namibia has about 2 million goats nationwide, most of which are found in communal areas and play an important economic role for sustainability of subsistence farming. Officially 200,000 to 250,000 goats are marketed annually, of which 95 percent is exported to South Africa. Boer goat breed is one of the breeds found in Namibia and considers as most resilient small stock breed with a great capacity for adaptation [3]. It is however of paramount importance to avail easily adaptable nutrient-rich plant species for maximum production and growth of goats; one of such plants is *Moringa oleifera* (*M. oleifera*) tree. *M. oleifera* leaves are readily eaten by cattle, sheep, goats, pigs and rabbits [4]. A feeding trial conducted with West African dwarf goats in Nigeria shows that *M. oleifera* leaves supplementation resulted in an average weight gain of 20.83 gram/animal/day [5]. A similar feeding trial revealed that supplementation of beef and dairy cows' diet with 40-50 percent of *M. oleifera* leaves led to an increase in milk yields for dairy cows and daily weight gains for beef cattle by 30 percent. Birth weight increased by 3-5 kg [6]. *M. oleifera* is well known for its enormous biomass production and it promises to be the plant of the future in ruminant animal supplementation strategy. Under high density cultivation, it yielded biomass in excess of 15 tonnes dry matter/hectare (DM/ha) in a 60-day growing cycle under the International Trypanotolerance Centre conditions in Banjul [7].

Research shows that every 100 grams of *M. oleifera* contain protein, vitamins, minerals, carbohydrates, fats, etc. in the following amounts: 6.7 g of protein in leaves, 2.5 g of protein in pods, 27.1 g of protein in leaf powder, 259 mg of potassium (K) in leaves, 259 mg of K in pods, 1,324 mg of K in leaf powder and 6.8 mg of vitamin A (β-carotene is precursor to Vitamin A) in leaves, 0.11 mg in pods and 16.3 mg in leaf powder [8]. *M. oleifera* has proven to be a valuable supplement for animals in other countries [9]; this means that feeding it to goats at the appropriate period of nutritional needs especially during pregnancy for proper foetus development and during lactation for kids' development is necessary. *M. oleifera* leaves have a high potential as a protein source supplement for ruminants and their feeding value is similar to that of the widely used soybean meal and rapeseed meal [10].

In Namibia, *M. oleifera* has not found much use as human food or feed for ruminants in comparison to other regions such as Asia and Western Africa [11], [12]. In addition, the time of kidding determines the period of highest nutritional demand, as late pregnancy and early lactation are critical times for the does and kids [13]. Therefore, the need for nutritional supplementation of does during this critical period, as well as in winter and drought when rangelands are less productive with less nutritional value is critical. It was hypothesized that *M. oleifera* supplemented diet has no indirect effect on growth rate parameters of pre-weaning Boer goat kids. Therefore, this study was aimed at evaluating the use of *M. oleifera* as a nutritional supplement for lactating does to meet their milk production requirement for proper early growth and development of their kids as suggested by Soliva *et al.* [14].

MATERIALS AND METHODS

Study area

This study was conducted at the Neudamm Experiment Farm, one of the campuses of the University of Namibia, about 30 km east of Windhoek with an area of 10, 187 hectares of land. Neudamm Campus is located at 22° 30′ 07″ latitude South and at 17° 22′ 14″ longitude East, and at an altitude of 1762 meter above sea level. The farm receives an annual average rainfall of 360 mm which is higher than the national annual average of 270 mm. The temperature ranges between a minimum of -7°C and a maximum 44°C [15]. The study was conducted during the period stretching from October, 2015 to January, 2016.

Study design

A completely randomized block design (CRBD) consisting of a one-way treatment structure was used in this trial. The treatment consisted of *M. oleifera* supplement at 4 inclusion levels (0 percent, 10 percent, 20 percent, and 30 percent) in isocaloric and isonitrogenous diets. Taking into consideration an average weight of 36 kg per goat, the percentages of inclusion translated into 0 percent (0 g), 10 percent (150 g), 20 percent (300 g) and 30 percent (450 g) of *M. oleifera* dry leaves per day as described by Gebregiorgis *et al*. [16] . Alfalfa or Lucerne (*Medicago sativa)* was used as a basal diet for all goats supplemented with 300 g Ram-Lamb-Ewe pellets. A control group (0 percent *M. oleifera*) was only fed with lucerne and pellets while three groups were supplemented with *M. oleifera* leaf at three inclusion levels (10 percent, 20 percent and 30 percent). All goats were fed twice a day (8:00 am and 3:00 pm) for 74 days and clean water was available *ad libitum* in all cages. Sixteen lactating Boer goats were randomly allocated to each treatment (4 per treatment) to assess the effect of *M. oleifera* leaf supplemented diet on growth rates of their pre-weaning kids through their mothers' increased milk production. The goats were housed in individual wire mesh cages and introduced to *M. oleifera* supplemented diet two weeks to one month after birth. Both does and kids were weighed prior to the introduction of *M. oleifera* supplemented diet. An adjustment period of 14 days as suggested by Sarwatt *et al*. [17] was observed to get animals used to the new diet, after which a 60-day trial period commenced. Feed given and refusals were recorded daily for the determination of daily feed intake [18], [19]. Body weights, body length and heart girth of kids were measured weekly throughout the 60-day trial period; however, only body weights and body condition scores of does were taken weekly.

Table 1: Experimental design of *M. oleifera* supplementation to lactating does

Treatment, *M. oleifera*: percent (g)	0 (0)	10 (150)	20 (300)	30 (450)	Total
Replications	4 goats	4 goats	4 goats	4 goats	N = 16 goats

Experimental animals

Lactating goats were purposefully targeted in the current study. Among these, 16 lactating Boer goats from a population of 51 total lactating goats at Neudamm Experimental Farm were randomly sampled for the present feeding trial since most nutritional deficiencies are common among lactating does and their kids [20]. The trial had 4 treatment levels with 4 goats in each treatment as replication. The animals were penned in individual pen with their kids. All the 16 pens had equal size of 430 cm x 13 cm square with taps providing water *ad libitum* and trace mineral salt blocks throughout the research period discussed by Juhnke [21]. Kids were separated from their mothers every day during *M. oleifera* feeding that lasted for 10-20 minutes and were re-united with their mothers afterward. The separation was meant to test for the indirect effect of *M. oleifera* on kids' growth. Kids were weighed and measured weekly to assess body weight gain, increase in body length and girth as well as body condition scores (BCS). Boer goats are more sensitive to external parasites than internal parasites [22]. At the beginning of this research, both does and kids were treated against ectoparasites using COOPERS SUPADIP (500 mL) at a dilution ratio of 50 mL: 10 L of water as previously used by

Gebregiorgis *et al.* [23]. At Neudamm Experimental Farm, Ivermectin (1 mL: 50 kg) and Dectomax (1 mL: 50 kg) are used to treat both ectoparasites and endoparasites, while Ecomectin (1 mL: 10 kg) is used to treat endoparasites.

Data collection

Lactating Boer goats with their kids and *M. oleifera* leaves were used as instruments for data collection. Collected data included weekly growth rates of kids and *M. oleifera* leaf supplemented ration as suggested by Abdulrazak *et al.*[24]) and Sanchez *et al*. [25] . Also, weekly body condition scores were assessed and recorded as described by Frost *et al*. [26] for both does and kids. A weighing scale and tapeline were used to measure weekly growth rates (heart girth, body length and weight) of kids as demonstrated by Olatunji-Akioye and Adeyemo [27]. Lactating goats were fed with *M. oleifera* leaf supplemented ration twice a day by 8:00 a.m. and 3:00 p.m. as discussed by Yayneshet *et al.* [28] using 4 percent body weight, which considered the wastes during feeding as deliberated by Coffey [29] . Daily rations were divided into two equal parts and given one portion by 8:00 a.m. and the other by 3:00 p.m. as described by Gebregiorgis *et al*. [30]. During the feeding of *M. oleifera* leaf supplemented ration, kids were separated from their mothers to avoid them directly consuming it. The separation was done to observe the indirect effect of *M. oleifera* on the kids. *Moringa oleifera* leaf ration was then given and consumed by the mothers within 10–20 minutes. Upon completion of the *M. oleifera* ration, kids were re-united with their mothers and given lucerne and pellets together while suckling at the same time.

Data analysis

The linear regression model and general linear model (GLM) were used to analyse data to establish if the different diets significantly affected the kids' growth rates at the 5 percent level of significance [31], [32]. Kids' body weights, length, heart girth and body condition scores served as dependent variables while *M. oleifera* supplement served as explanatory (factor) variable. The Statistical Package for Social Sciences (SPSS® version 23) and Microsoft Office Excel® program were used for all data analyses.

RESULTS

The results obtained from this study include growth performance parameters (heart girths, body lengths, and weights as well as body condition scores) of kids used in the study that suckled from does fed *M. oleifera* supplemented rations compared to a control group taken weekly for the 74 days period. Figures and tables were used to compare growth parameters of kids both descriptively and statistically. The results of statistical analyses reveal significant differences of growth parameters of kids whose mothers were fed with *M. oleifera* supplemented diet compared to the control (kids not indirectly fed *M. oleifera*).

Adjustment period

The goats were gradually introduced to *M. oleifera* supplement 14 days prior to the actual start of the feeding experiment as part of adaptation/adjustment period as suggested by Yayneshet *et al*. [33] . During this period, it was observed that 15 out of the 16 (93.8 percent) goats liked *M. oleifera* leaves in less than a week and consumed their entire ration. This confirms the view of Mpofu [34] who discussed that goats feed on a wide variety of feeds ranging from tree and shrub leaves and grasses; thus, making them hardy to survive under difficult conditions. However, one of the goats could not adjust immediately, but gradually did. The quick adaptation of goats to *M. oleifera* leaf supplemented diet serves as an advantage of using it as hay, nutritional supplement or anthelmintic drug for goats and other livestock species as reported in a number of studies [35], [36], [37], [38].

Kids' birth types and sex

Does used in the study had single and twins birth types with kids comprising of male and female sex. Figure 1 shows the birth types and sex of kids. A total of 20 kids were used in this research in which 12 (60 percent) were of single birth, and eight (40 percent) were twins with 11 (55 percent) males and nine (45 percent) were females. Thus, from the 16 lactating does used in the study, 12 had single births while four had twins.

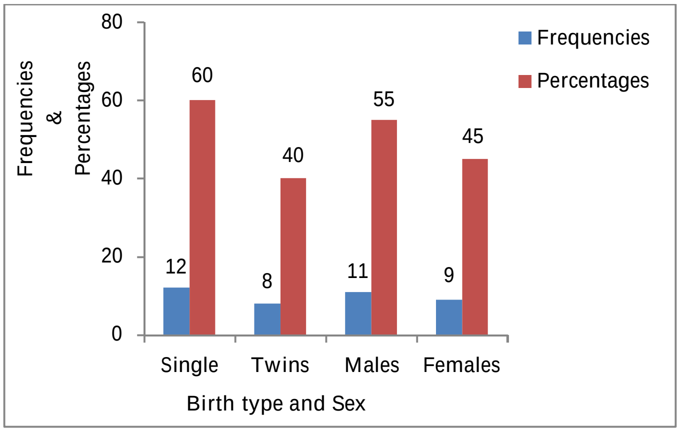

Fig. 1: Birth type and sex of kids

Research goats were divided into four groups according to *M. oleifera* supplemented diet inclusion levels, which were zero percent (control), 10 percent (150 g), 20 percent (300 g) and 30 percent (450 g). The figures and tables present comparisons of differences in the four groups' growth rate parameters of kids.

Average and statistical differences of kids' girth

The comparison of kids' heart girth growth based on *M. oleifera* inclusion levels is shown in Fig.2. The result revealed that 10 percent *M. oleifera* inclusion level had the highest growth in kids' girth (48.55 cm, 49.67 cm, 50.36 cm, 51.54 cm and 52 cm). The second highest in kids' girth growth was 20 percent inclusion level (44.56 cm, 46.45 cm, 50.82 cm, 51.27 cm and 51.45 cm), which was followed by 30 percent inclusion level (44.27 cm, 44.82 cm, 49.64 cm, 50.36 cm and 51.36 cm); and the least was the control (0 percent) inclusion level (42.64 cm, 46.55 cm, 49.90 cm, 49.36 cm and 49 cm).

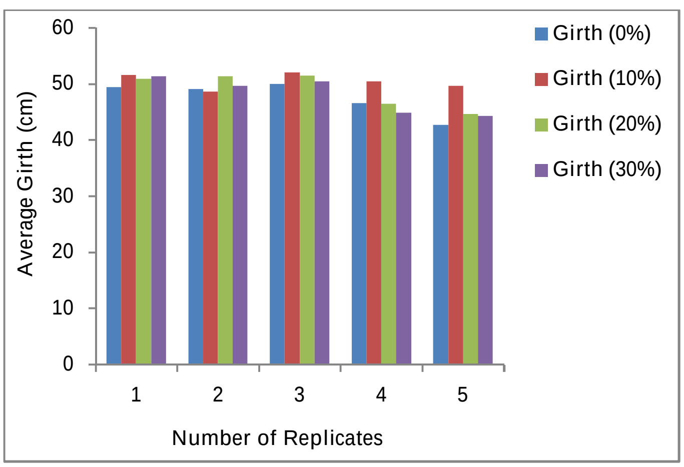

Fig. 2: Comparison of average kids' girth at different *M. oleifera* inclusion levels

Table 2 presents the linear regression analysis of *M. oleifera* inclusion levels on the kids' girth growth and time in weeks. The result reveals that *M. oleifera* levels and weeks had positive effect (P < 0.05) on the kids' girth increase at the 10 percent (150 g) and 20 percent (300 g), but this was not the case at the 30 percent (450 g) inclusion level and week one (P > 0.05).

Table 2: Regression analysis of kids' Girth (cm) over time and *M. oleifera* levels

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	40.527	0.828		48.930	0.000
Dum level 10%	2.091	0.626	0.165	3.339	0.001
Dum level 20%	1.109	0.626	0.087	1.771	0.078
Dum level 30%	0.691	0.626	0.054	1.103	0.271
Week1	0.600	1.038	0.031	.578	0.564
Week2	2.050	1.038	0.107	1.974	0.050
Week3	4.050	1.038	0.212	3.901	0.000
Week4	6.000	1.038	0.314	5.779	0.000
Week5	7.700	1.038	0.403	7.416	0.000
Week6	8.550	1.038	0.447	8.235	0.000
Week7	9.250	1.038	0.484	8.909	0.000
Week8	10.700	1.038	0.559	10.305	0.000
Week9	12.000	1.038	0.627	11.557	0.000
Week10	13.700	1.038	0.716	13.195	0.000

Average and statistical differences of kids' length

The mean comparison of kids' length growth based on the four *M. oleifera* inclusion levels are shown in Fig.3. The analysis shows that 30 percent inclusion level had the highest increase in length (42.45 cm, 42.18 cm, 45.36 cm, 46.64 cm, and 49 cm). Twenty percent had the second highest increase in length (42.55 cm, 42.18 cm, 45.81 cm, 46.18 cm and 48.27 cm), follow by 10 percent inclusion level (42.45 cm, 44.81 cm, 44.81 cm, 45.06 cm and 47.45 cm); and, the control (zero percent inclusion level) had the least increase in length (40.09 cm, 41.91 cm, 42.27 cm, 44.18 cm and 45.09 cm), respectively.

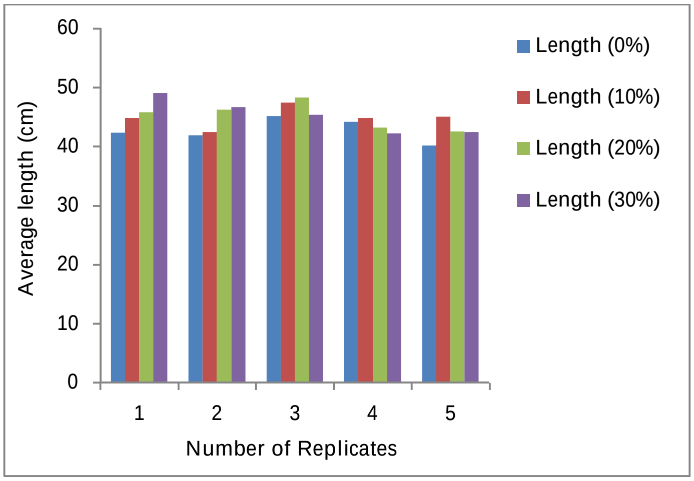

Fig. 3: Comparison of average kids' length at different *M. oleifera* inclusion levels

Table 3 presents the linear regression analysis of *M. oleifera* inclusion levels on the kids' length growth over time in weeks. The result shows that *M. oleifera* inclusion levels had significant effect (P < 0.05) on kids' length growth at all three inclusion levels over time (weeks), although 10 percent was less significant than 20 and 30 percent's. Weeks were also had significant differences (P < 0.05) on kids' length growth except for weeks one and two that had no differences (P > 0.05).

Table 3: Regression analysis of kids' length (cm) over time and *M. oleifera* levels

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	37.409	0.733		51.060	0.000
Dum level 10%	1.218	0.554	0.108	2.200	0.029
Dum level 20%	2.145	0.554	0.190	3.874	0.000
Dum level 30%	2.200	0.554	0.194	3.972	0.000
Week1	0.400	0.918	0.023	.436	0.664
Week2	0.300	0.918	0.018	.327	0.744
Week3	2.650	0.918	0.155	2.885	0.004
Week4	2.900	0.918	0.170	3.158	0.002
Week5	4.100	0.918	0.240	4.464	0.000
Week6	5.950	0.918	0.349	6.478	0.000
Week7	9.050	0.918	0.531	9.854	0.000
Week8	8.800	0.918	0.516	9.582	0.000
Week9	10.100	0.918	0.592	10.997	0.000
Week10	10.650	0.918	0.625	11.596	0.000

a. Dependent Variable: Kid length; R-Square= 0.671; F-Statistics= 32.362; N= 220 & Durbin-Watson Test = 1.322

Average and statistical differences of kids' weights

The mean comparison of kids weight gain based on *M. oleifera* inclusion levels is found in Fig. 4. The analysis confirms that 20 percent inclusion level had the highest kids' weight gain (7.76 kg, 9.7 kg, 10.92 kg, 11.09 kg and 11.91 kg). The 30 percent inclusion level had the second highest weight gain (7.91 kg, 8.27 kg, 10.27 kg, 11.73 kg and 11.76 kg,), which was followed by 10 percent inclusion level (8.78 kg, 10.38 kg, 10.80 kg, 11.00 kg and 11.47 kg). Finally, the zero percent inclusion level (control) had the least weight gain (6.98 kg, 8.35 kg, 8.84 kg, 9.49 kg and 11.25 kg). The zero percent inclusion level (control) having the least kids' weight gain demonstrates the effect of *M. oleifera* on growth parameters.

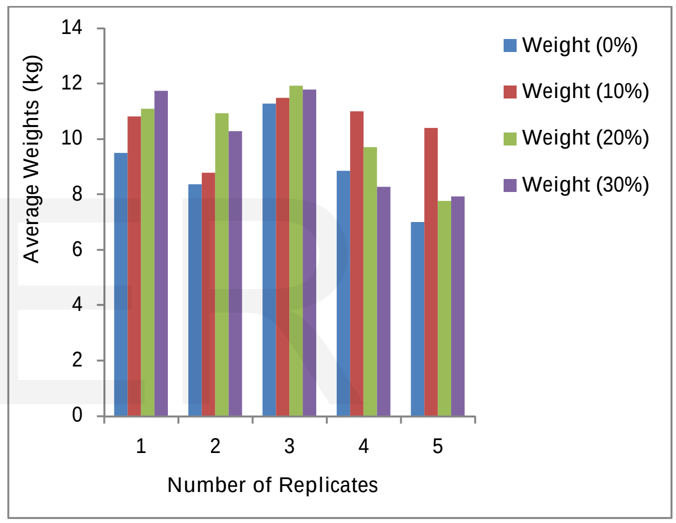

Fig. 4: Comparison of average kids' weight at different *M. oleifera* inclusion levels

Table 4 presents a linear regression analysis result of kids' weight gain as explained by *M. oleifera* inclusion levels and time. The result shows that *M. oleifera* and time had significant differences (P < 0.05) on kids' weight gain, except for week one that had no effect statistically.

Table 4: Regression analysis of kids' weight (kg) over time and *M. oleifera* levels

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	4.873	0.449		10.847	0.000
Dum level 10%	1.127	0.340	0.145	3.320	0.001
Dum level 20%	1.295	0.340	0.167	3.812	0.000
Dum level 30%	1.007	0.340	0.130	2.966	0.003
Week1	.440	0.563	0.038	.781	0.435
Week2	1.365	0.563	0.117	2.424	0.016
Week3	2.030	0.563	0.174	3.605	0.000
Week4	3.030	0.563	0.260	5.381	0.000
Week5	4.370	0.563	0.374	7.761	0.000
Week6	5.095	0.563	0.437	9.048	0.000
Week7	5.730	0.563	0.491	10.176	0.000
Week8	6.620	0.563	0.567	11.756	0.000
Week9	7.740	0.563	0.663	13.745	0.000
Week10	8.780	0.563	0.752	15.592	0.000

a. Dependent Variable: Kid weight; R-Square= 0.736; F-Statistic= 44.223; N= 214 & Durbin-Watson Test = 1.252

Average and statistical differences of kids' body condition scores

Fig.5 show kids' average body condition scores (BCS). The analysis of BCS indicates that 10 percent *M. oleifera* inclusion level led to the highest BCS of 3.5 points but had one that was 2.5 points, while 20 percent and 30 percent had equal BCS of 3 points, and the zero percent (control) had two kids with 2.5 BCS, which means that zero percent had the highest number of kids with 2.5 points.

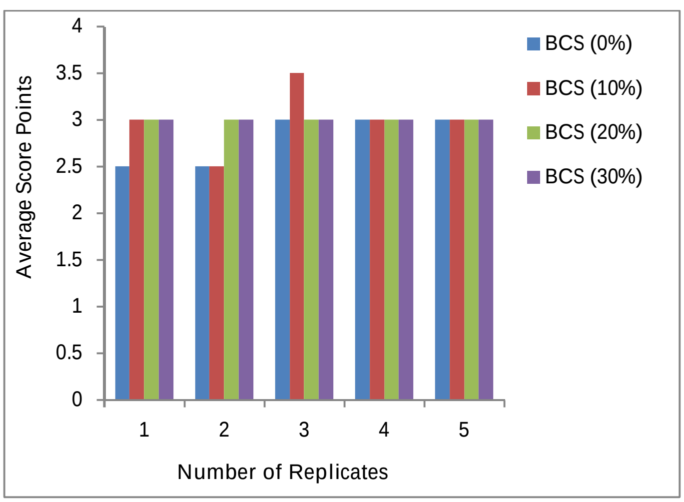

Fig. 5: Comparison of kids' average BCS at different *M. oleifera* inclusion levels

Table 5 presents a linear regression analysis of the body condition scores (BCS) of kids indirectly fed *M. oleifera* over time. The result indicates that *M. oleifera* had significant effects ($P < 0.05$) on the BCS of kids over time in weeks. Thirty percent had more effect on kids' growth compared to 10 and 20 percent.

Table 5: Regression analysis of kids' body condition scores over time and *M. oleifera* levels

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	2.473	0.084		29.302	0.000
Dum level 10%	0.127	0.064	0.120	1.995	0.047
Dum level 20%	0.109	0.064	0.103	1.710	0.089
Dum level 30%	0.173	0.064	0.163	2.708	0.007
Week1	0.375	0.106	0.235	3.545	0.000
Week2	0.475	0.106	0.298	4.490	0.000
Week3	-0.425	0.106	-0.266	-4.018	0.000
Week4	0.300	0.106	0.188	2.836	0.005
Week5	0.450	0.106	0.282	4.254	0.000
Week6	0.625	0.106	0.391	5.908	0.000
Week7	0.600	0.106	0.376	5.672	0.000
Week8	0.450	0.106	0.282	4.254	0.000
Week9	0.575	0.106	0.360	5.436	0.000
Week10	0.775	0.106	0.485	7.326	0.000

a. Dependent Variable: Kid BCS; R-Square = 0.503; F-Statistic = 16.008; N = 220 & Durbin-Watson Test = 1.651

Average and statistical differences of kids' growth by sex and birth types

Table 6 presents the average growth parameters of kids which reveal that males grew faster and bigger than females in heart girths, body lengths, body weight gains and even had better body condition scores. As per birth types, single males had the highest average growth parameters (heart girth 54.24 cm, body length 48.72 cm and body weight 13.07 kg), followed by twin males in girth (51.99 cm) and weight gains (11.04 cm) but not length (44.31 cm). Conversely, single females had higher length (45.67 cm) and body condition scores (3.18), while twin females had the least growth parameters of all the groups. Individually, the heart girth ranges between 50 cm to 60 cm, length 45 cm to 54 cm and weight 11.2 kg to 20 kg.

Table 6: Average growth parameters of kids by birth types and sex

Birth	Sex	No. of kids	Heart Girth (cm)	Length (cm)	Weight (kg)	Body Condition Scores
Single	Male	6	54.24	48.72	13.07	3.43
Single	Female	6	49.98	45.67	10.84	3.18
Twin	Male	5	51.99	44.31	11.04	2.73
Twin	Female	3	50.74	43.69	9.45	2.47
Single	Aggregate	12	52.11	47.19	11.96	3.90
Twin	Aggregate	8	51.36	44.00	10.25	2.60

Table 7 presents a General Linear Model (GLM) multivariate pairwise comparisons of *M. oleifera* effects on kids' heart girth, length, weight and BCS using a least significant difference (LSD) post hoc analysis with weeks as covariate on the male and female kids. The LSD result reveals that there were significant differences (P < 0.05) between males and females kids' growth rates over time (weeks).

Table 7: GLM Pairwise comparisons of kids' growth parameters on sex

Dependent Variable	(I) Sex	(J) Sex	Mean Difference (I-J)	Std. Error	Sig.[c]	95 percent Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Kid girth	Female	Male	-3.072*	0.385	0.000	-3.836	-2.309
	Male	Female	3.072*	0.385	0.000	2.309	3.836
Kid length	Female	Male	-2.276*	0.372	0.000	-3.012	-1.540
	Male	Female	2.276*	0.372	0.000	1.540	3.012
Kid weight	Female	Male	-2.197*	0.196	0.000	-2.586	-1.809
	Male	Female	2.197*	0.196	0.000	1.809	2.586
Kid BCS	Female	Male	-0.116*	0.041	0.006	-0.197	-0.035
	Male	Female	0.116*	0.041	0.006	0.035	0.197

Based on estimated marginal means

*. The mean difference is significant at 0.05 level.

a. Weighted Least Squares Regression - Weighted by MOL consumed

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 8 presents GLM multivariate pairwise comparisons of *M. oleifera* effects on kids' heart girth, length, weight and BCS using a least significant difference (LSD) post hoc analysis with weeks as covariate on birth-types (single and twin birth) of kids over time in weeks. The LSD multiple comparisons results indicate that kids' growth parameters were significantly different (P < 0.05) by birth-types; that is, between single and twin births.

Table 8: Pairwise comparisons of *M. oleifera* effect on kids growth parameters on birth types

Dependent Variable	(I) birth type	(J) birth type	Mean Difference (I-J)	Std. Error	Sig.[c]	95 percent Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
Kid girth	Singles	Twins	-1.811*	0.385	0.000	-2.575	-1.047
	Twins	Single	1.811*	0.385	0.000	1.047	2.575
Kid length	Single	Twins	-1.483*	0.372	0.000	-2.220	-0.747
	Twins	Single	1.483*	0.372	0.000	0.747	2.220
Kid weight	Single	Twins	-0.520*	0.196	0.009	-0.909	-0.132
	Twins	Single	0.520*	0.196	0.009	0.132	0.909
Kid BCS	Single	Twins	0.113*	0.041	0.007	0.032	0.195
	Twins	Single	-0.113*	0.041	0.007	-0.195	-0.032

Based on estimated marginal means

*. The mean difference is significant at the 0.05 level.

a. Weighted Least Squares Regression - Weighted by MOL consumed

c. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Discussions

Figures 2 to 5 compared kids whose mothers were fed with *M. oleifera* supplemented diet with the control (kids not indirectly fed *M. oleifera*) growth parameters (heart girth, body length and weight as well as body condition scores) individually. Table 2 to 8 compared those growth parameters statistically to determine significant differences, except for Table 6 which compares kids by birth types and sex.

The comparison of kids' heart girth growth indicates that 10 percent (150 g) and 20 percent (300 g) *M. oleifera* inclusion levels can meet the nutritional needs of lactating Boer goats *ceteris paribus*, while 30 percent (450 g) resulted into diminishing returns to scale (Figure 2). Thus, it means that it is no longer economical to feed more than 20 percent inclusion level of *M. oleifera*. This result confirms findings obtained by Lu [39] that Boer goats have gained worldwide recognition for excellent fast growing rate. The linear regression analysis was conduct to test significant differences of *M. oleifera* inclusion levels on the kids' girth growth and time in weeks (Table 3).

It was noticed that feeding 150 g and 300 g of *M. oleifera* to lactating goats would economically result into maximum productivity of does and increase of kids' girth. Contrary, any rate of increase beyond these inclusion level would result into economic loss since *M. oleifera* is costly, scarce and in demand for human use as emphasized by Radovich [40] and Edward *et al.* [41] . Furthermore, girth growth over time was also significantly different (P<0.05) except in week one where there was no statistically significant increase in girth at the different *M. oleifera* inclusion levels and the control.

The mean comparison of kids' length growth revealed that 30 percent (49 cm) was highest, followed by 20 percent (48.27 cm) and 10 percent (47.45 cm) with the least zero percent (45.09 cm). This implies that kids' length growth depended on *M. oleifera* inclusion levels sequentially; that is, as the level of *M. oleifera* supplemented diet increases, the kids responded simultaneously (Figure 3). The linear regression analysis of *M. oleifera* inclusion levels on the kids' length growth over time in weeks was employed to statistically test the significant differences of growth. It was observed that 10 percent (150 g) *M. oleifera* inclusion level had less effect on growth in length compared to 20 percent (300 g) and 30 percent (450 g) inclusion levels that are statistically more conspicuous (Table 4). This less effect may have been attributed to less intake of milk as the kids grew bigger towards weaning period and exposed to consuming concentrates and folders by themselves as suggested by Mpofu [42].

The average comparison of kids weight gain shows that 20 percent had the highest, followed by 30 percent and 10 percent with the least of zero percent which clearly indicates that the control (zero percent) had least weight gains among all kids (Figure 4). Lu [43] reported that among all superior traits, heavier body weight and faster growth rate are the most notable of Boer goat kids. In a research with West African Dwarf goat kids, Asaolu *et al*. [44] concurred that supplementing *M. oleifera* resulted into a significant weight gain compared to *Gliricidia sepium* and *Leucaena leucocephala* fodders. In the present study, *M. oleifera* supplement diet increased weight gain than those fed with only lucerne and pellets diet. The linear regression analysis result of kids' weight gain over time in weeks shows significant differences of kids by treatments. It was shown that *M. oleifera* inclusion levels (treatments) had positive effect on weight gain of kids over time (weeks), which indicates that all inclusion levels were economically potential contributors to weight gain as time progressed (Table 5). Gebregiorgis *et al*. [45] affirmed that feeding Moringa leaf to sheep increased body weight gain (P < 0.05) with increasing levels of Moringa leaf (300 g and 450 g), but not in the control group.

Just as the kids' girth, length and weight had the least value among the zero percent *M. oleifera* inclusion levels, it also applies to body condition scores (BCS) with the least being more among the zero percent (Figure 5). Body condition scores range from 1 to 5 with 0.5 increments and were assessed by visual observation and tactile as suggested by Frost *et al*. [46] . In the present study, kids' BCS lie between 2.5 to 3.5 points. This suggests that most of the kids were between moderate to good BCS as below 2 is considered thin [47]. These good BCS of kids under the drought conditions the present research was conducted is an indication that kids had sufficient milk from their mothers which sustained proper early growth and development. Villaquiran *et al*. [48] explained that in most cases, healthy goats should have BCS of 2.5 to 4.0. The BCS of 1.0, 1.5, or 2.0 indicate a management or health problem. A BCS of 4.5 or 5 is almost never observed in goats under normal management conditions; however, it can sometimes be observed in show goats. On the other hand, a BCS of 1 is extremely thin and 5 is considered as obese or very over-conditioned [49 , [50 . The linear regression analysis of the BCS of kids indirectly fed *M. oleifera* over time was used to test the significant differences in kids. The BCS were best at 30 percent inclusion level (450 g) compared to 10 percent (150 g) and 20 percent (300 g) levels respectively (Table 6). This is a clear indication that *M. oleifera* supplemented diet contributed significantly to the nutritional needs of the does; thus, having direct effects on kids' BCS. It implies that the demand for the quantity of milk needed by kids whose mothers were not supplemented with *M. oleifera* ration was unmet.

The average growth parameters of kids reveals that males grew faster and bigger than females in heart girths, body lengths, body weight gains and even had better body condition scores (Table 6). This confirms the findings by Lu [51] who stated that Boer goats male kids have higher body weight and post-weaning growth rate under standardized conditions. Weight range in the present study is lower than what was estimated by Agra Professional Services [52] which reported that 100 days–old kids weigh between 25 kg to 32 kg. The aggregate for birth types shows that single-births grew faster and bigger than twins. The GLM multivariate pairwise comparisons of *M. oleifera* effects on kids' heart girth, length, weight and BCS using a least significant difference (LSD) post hoc analysis results indicate that male kids were significantly different in all growth parameters over time (weeks) regardless of the *M. oleifera* level on kids growth in girth, length, weight gains and BCS between (males and females). This implies that the growth parameters of male kids measured in this study were better than that of the female kids fed with *M. oleifera* at all levels (Tables 6 and 7). The GLM multivariate pairwise comparisons of *M. oleifera* effects on kids' heart girth, length, weight and BCS using a LSD post hoc analysis with weeks as covariate on birth-types (single and twin birth) of kids over time in weeks was used to test kids' statistical differences (Table 8). These differences might be attributed to the fact that singles were born bigger and heavier and suckled their mothers alone no matter how much milk they produced while twins were smaller and lighter and had to share the milk produced by their mothers. This offers chances for single kids to grow faster and bigger than twins. Zhang *et al*. [53] concurred that singles have the heaviest birth weight and largest body size. Although in this study, the result indicated that twins had greater growth parameter values than single births contrary to the expectation, this could be supported by the fact that males grow faster and bigger than females as pointed out in these results where there were more twin males than twin females and single births.

Conclusion

The supplementation of *M. oleifera* to lactating Boer does at all three different inclusion levels had positive indirect effect on all growth parameters of their kids which included heart girth, body length and weight as well as body condition scores. They were all statistically significant. Although Boer goats are known for their fast growth under favorable conditions, feed supplementation of pregnant and lactating does could be advantageous for maximum milk production to support their kids' healthy early growth and development especially under unfavorable conditions such as during winter and drought. This study was done under severe drought conditions after 2015 winter season. Therefore, in a semi-arid, driest and drought persistent country like Namibia, *M. oleifera* would bring a possible solution for animal supplementation during drought and winter periods since *M. oleifera* grows very fast and produces more leaf biomass per hectare; thus, alleviating farmer's stress of purchasing feed-supplement during pregnancy and lactation period. This was demonstrated by the present study where *M. oleifera* leaf supplemented diet of lactating Boer goats had positive effect on growth parameters (girth, length and weight) of their kids.

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